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LAW, DESCRIPTION AND HYPOTHESIS IN THE ELECTRICAL SCIENCE[1]

YOUR invitation to deliver the first Steinmetz lecture I consider a very great honor. The late Doctor Steinmetz was a dear friend of mine. I met him in Yonkers in 1889, and from that time on until his death we were tied to each other by bonds of personal sympathy and scientific interest, which was a source of uninterrupted pleasure to both of us.

This lecture is an attempt to describe briefly how Faraday and Maxwell, starting from definite laws which were discovered by experiment, created the modern electromagnetic theory by a prophetic use of description and hypothesis and how this theory furnishes the foundation of the science of electrical engineering. Our knowledge of electrical phenomena began its career as a science when it started to build upon a foundation of a quantitative law. Coulomb's law marks, therefore, the beginning of the electrical science. It says that two electrical point charges in a vacuum act upon each other with a mechanical force which is equal to the product of the two charges divided by the square of the distance between them.

In its mathematical form Coulomb's law is identical with Newton's law of gravitational action. Many theorems which the mathematical physicists of the eighteenth and the beginning of the nineteenth century had developed in their analysis of gravitational fields of force were, apparently, directly applicable to the analysis of electrical fields. This was very fortunate, because it attracted some of the best mathematical minds of those days to the electrical science. This raised its standing among the sciences which it badly needed.

Newton's great essay, "Principia Philosophiae Naturalis," published in the beginning of the eighteenth century, created a new school of natural philosophers which dominated during the eighteenth century the scientific mental attitude of the world. No natural philosopher of those days could expect to attract serious attention who departed from the rigorously mathematical methods of this school. Even so great a natural philosopher as Benjamin Franklin may be said to have been snubbed by the Royal Society, when it refused to publish in its transactions Franklin's communications describing his electrical experiments. These experiments, suggested by and clustering around

[1] The first Steinmetz lecture delivered on May 8, 1925, before the Schenectady section of the American Institute of Electrical Engineers.

Leyden jar discharges, had no obvious connection with the Newtonian school of natural philosophy of the eighteenth century and, therefore, the Royal Society failed to recognize their full significance. One may imagine how welcome Coulomb's law was to some natural philosophers of the eighteenth century, to whom Newton's Principia was as final as the book of Genesis is to some people of our own generation.

Faraday was the first to point out a fundamental difference between Newton's law of gravitational action and Coulomb's law of electrical action. The action of a gravitational mass upon another gravitational mass is not influenced by the medium separating the two, but the action of an electrical charge upon another electrical charge is influenced very much by the medium separating the two. Coulomb's law, unaided by other considerations, was unable to explain this difference. Additional knowledge was needed which Coulomb did not possess. Faraday was the first to enter into these considerations, and his first guide may be said to have been a hypothesis which maintained that all electrical charges trace their origin to the molecules and atoms of material bodies, which in their normal state contain, according to Franklin, the same amounts of positive and negative charges. This hypothesis of the atomic origin of electrical charges was undoubtedly suggested by Faraday's classical studies of the behavior of electrolytes, which revealed a new truth, namely, that a definite electrical charge is attached to each valency of atoms. The granular structure of ordinary electrical charges and the whole modern electron theory was first foreshadowed in these experiments. But how did this hypothesis affect Coulomb's law of force between Coulomb charges which are surrounded by a material medium?

Consider the insulators. The hypothesis suggested that in an insulator each molecule contains a definite quantity of positive and an equal quantity of negative charge which can be separated from each other by the action of an external electrical force impressed upon them, but that the distance of separation can not exceed the dimensions of the molecule. Adopting this picture of the electrical structure and behavior of insulators there was readily deduced a modified form of Coulomb's law of force between charges separated by an insulating medium, and this modified form of Coulomb's law says: *The force between two point charges in an iusulating material medium is equal to that in a vacuum divided by a constant, called the specific inductive capacity of the material medium.*

But experiment told us that the hypothesis mentioned above concerning the process of separating molecular charges and everything inferred from it can be only approximately true, because the specific inductive capacity of material insulators is usually neither constant nor does it always have a definite meaning. This law, therefore, could not be taken as our infallible guide in the study of the electrical fields of force in material insulators. The question arose then: Is there any other law to which we can appeal for guidance? Faraday's study of the electrical action of insulators, a subject to which Benjamin Franklin first drew attention, showed a way leading to the answer of this question. This study suggested one of the two great foundation pillars of the modern electromagnetic theory, which I venture to describe here briefly.

Faraday's method of representing graphically the field of force of electrical charges is well known, and it finds its simplest illustration in the well-known conical tubes of force drawn from a point charge as vertex and expanding into all space. We are also familiar with Faraday's tubes[2] of force for any distribution of electrical charges. Faraday's pictorial method of describing the field of force leads to the same numerical results as Coulomb's law when the surrounding medium is free space without any material bodies in it. When, however, the surrounding medium contains material insulators then Coulomb's law offers small assistance in our study when these insulators have a variable specific inductive capacity and deviate otherwise from the characteristics of an ideal dielectric. It will be pointed out below that there are electric and magnetic fields which are not due to charges and in which Coulomb's law is altogether inapplicable. Faraday's picture of the field in terms of the tubes of force suggested to Maxwell a new law of force which is broader than Coulomb's law both in its meaning and its applicability.

Faraday's ideas concerning the physical character of the tubes of force were a guide to Maxwell, whose earliest studies of electrical phenomena, while still an undergraduate at the University of Cambridge, related to Faraday's "Physical Lines of Force." In these early studies Maxwell made wonderful attempts to show by imaginative description and ingenious mechanical models what he saw in Faraday's tubes. But all these things were only a temporary scaffolding around a new structure which Maxwell was building. When the structure was finished the scaffolding disappeared and what do we see to-day? I shall try to answer this question. In Maxwell's mind, just as in the mind of Faraday, the tubes of force were not mere geometrical pictures but represented physical entities capable of actions and reactions. Each volume element of a tube of electric force is according to Faraday and Maxwell the seat of an electrical re-

[2] The term "tubes" is preferable here to "lines" because it brings out clearly the three-dimensional character of these structures.

action against the change of its density, that is, of the number of tubes per unit area. When the surrounding medium is a vacuum or an ideal insulator, that is, a dielectric with a constant specific inductive capacity, then the numerical value of this reaction can be calculated. According to Maxwell's hypothesis, the electrical reaction in this case per unit length and unit cross-section of the tube is equal to the density of the tubes in the direction in which the reaction is considered, divided by the specific inductive capacity. The hypothetical reaction had a most significant corollary; it located the energy of the field in the volume elements of the tubes of force and assigned to each element, per unit of volume, an amount proportional to the square of the density of the tubes of force at that volume element. Dynamically, therefore, there is a perfect resemblance between the field of electrical reactions in ideal insulators and the field of elastic reactions in the interior of an elastically strained body which obeys the so-called Hooke's law.

According to this view, the charges transmit their action through the volume elements of the tubes against the reaction of the tubes. *When the field of electrical force is in equilibrium then the external actions coming from the electrical charges and the internal electrical reactions of the tubes are equal and opposite to each other at every point of space.*

This form of statement is suggested by Newtonian dynamics and furnishes a law which conforms to Newton's third axiom. It is different from Coulomb's law in form and meaning, and it holds good no matter how the impressed electrical forces are generated or what the physical character of the material insulators is upon which these forces are impressed. It is obtained from the hypothesis that the tubes of force are physical entities which react against a change of their density. There is nothing in Coulomb's law which suggests this hypothesis and there can not be, because this law suggests nothing concerning the velocity or the mechanism of transmission of force between electrical charges, whereas a reacting tube of force was suggested to Faraday and to Maxwell by the intuition that electrical actions are transmitted through the tubes of force with a finite and definite velocity which depends upon the dynamical properties, that is, upon the reactions, of the tubes. The tubes of force attached to electrical charges or otherwise generated are, according to this hypothesis, the transmitting mechanism reacting in every one of its elements by reactions which in the case of the vacuum and of ideal dielectrics are identical in form with the elastic reactions of an ideal elastic body. This view of the field of electrical force is one of the foundation pillars of the Faraday-Maxwell electromagnetic theory. I shall next describe briefly the second foundation pillar of this theory.

What has been said above about our knowledge of electrical phenomena is also true of our knowledge of magnetic phenomena. It started its career as a science when Coulomb's measurements succeeded in formulating a law of force between magnetic charges. Since this law is identical in form with that for electrical charges, and since the presence of material bodies affects similarly a magnetic field as the presence of material insulators affects an electrical field it is obvious that the Faraday-Maxwell intuitive philosophy leads here to the same results as in the case of electrical fields of force. Coulomb's law can, therefore, be replaced by a law which is identical in form with the law formulated above for electrical fields. It is as follows: *When the field of magnetic force is in equilibrium then the external magnetic actions and the internal reactions of the magnetic tubes of force are equal and opposite to each other at every point of space.* Description and hypothesis serve here the same object as in the case of the electric fields, namely, to point out that the magnetic tubes of force are the transmitting mechanism of the magnetic force and that the quantitative relation between the forces impressed upon the tubes and their reactions is one of the determining factors of the mode of propagation.

It is obvious that so far I have been endeavoring to show that Faraday's and Maxwell's views paved the way to the formulation of new concepts, the concepts of electrical and magnetic actions and reactions, which like ordinary material actions and reactions obey Newton's third law. These endeavors will be continued in what follows.

The law of equality between electrical and magnetic actions and the respective reactions in fields which are in static equilibrium can, obviously, tell nothing definite about the velocity of propagation. Reactions brought into play when this equilibrium is disturbed must be considered. Do they exist, and if so, do they show that the velocity of propagation of electrical force is the same as or different from that of the magnetic force? The electrical science prior to Oersted's and Faraday's discoveries could not have answered this question. These discoveries supplied the necessary knowledge. Broadly stated, they revealed the following new truth: Oersted discovered that electrical charges moving through conductors produce magnetic tubes of force which are interlinked with the conductors; Faraday discovered that magnetic charges and their tubes of force produce by their motion or variation electrical forces in conducting circuits which are interlinked with these tubes. This description of the discoveries intentionally emphasizes the two facts, namely, that Oersted made his discovery while experimenting with conduction currents, and that Faraday explored the electrical field in conducting wires, only,

which are interlinked with the magnetic tubes of force. The laws resulting from these experiments, namely, Ampère's law and Faraday's law, were necessarily limited to the conditions of the experiments which led to their formulation. Neither one nor the other were sufficiently general to give direct information concerning the unknown reactions associated with the variable electric and magnetic tubes of force at any point of a dielectric. Oersted's and Faraday's experiments did not detect them, nor was it obvious how to detect them experimentally. New hypotheses were needed and Maxwell was the first to formulate them; they were as follows: First, a variation of the flux, that is, of the total number of electrical tubes of force through any area, is equivalent to the motion of electrical charges through that area; in other words, the so-called displacement current produces according to Maxwell the same magnetic effect as the conduction or convection current. Secondly, the variation of the flux of the tubes of magnetic force through any area produces an electromotive force around the boundary curve of this area which is independent of the material through which this boundary curve passes. These two hypotheses extended the meaning of the Ampère and of the Faraday law and gave them that symmetry which is expressed in the following statements:

The rate of variation of the electric flux through any area is equal to the magnetomotive force in the circuit which forms the boundary curve of that area.

The rate of variation of the magnetic flux through any area is equal to the electromotive force in the circuit which forms the boundary curve of that area.

The first statement represents Maxwell's generalization of Ampère's law, and the second that of Faraday's law. Mathematical physicists call them Maxwell's field equations. This name does not convey clearly their physical meaning, nor does it express fully their historical significance. Prior to the time of Oersted and Faraday there were only a few, rather feeble, processes of generating and impressing upon material bodies electric and magnetic forces; frictional machines, galvanic cells, action of permanent magnets, etc. . . . Ampère's and Faraday's generalized laws describe new processes of generating and impressing magnetic and electric forces upon *any part of space.* They might be called Maxwell's laws of electrodynamic generation, or briefly *Maxwell's laws,* the rest of the proposed title being understood. These laws give the total sum of the electric and magnetic forces impressed by those processes upon any circuit; the energy principle tells us that this sum is equal to the sum of the electric and of the magnetic reactions in the circuit. The parcelling out of the total impressed forces thus generated among the volume elements of the circuit and the character of the reactions of each volume element must be determined by the character of each problem and by the physical properties of each volume element of the circuit. Circuits in ideal isotropic dielectrics present the simplest illustration of the general procedure, and this was the subject which Maxwell considered first. In this case the reaction per unit cross-section and unit length of the circuit is, as already pointed out, equal to the ratio of the flux density to the specific inductive capacity, or permeability, respectively, and this reaction must be equal to the force generated by the variable fluxes and impressed per unit length of the circuit. This leads to a reciprocal relation between the electric and magnetic reactions in variable fields which in an isotropic dielectric exhibits a process of propagation identical in form with that obtained by Newtonian dynamics for the actions and reactions in an isotropic, incompressible, elastic medium. Maxwell's greatest achievement is, in my opinion, his introduction into the electrical science of new concepts, electric and magnetic actions and reactions, which obey the same laws as the corresponding concepts in Newtonian dynamics. But it should be observed here that Maxwell's success was due to Faraday's suggestive description of the electric and magnetic fields in terms of tubes of force and to the intuition which created the epoch-making hypotheses endowing these tubes with dynamical attributes formerly belonging to material substances only. These hypotheses demanded experimental verification; Hertz seized the opportunity and furnished the epoch-making demonstration of the correctness of Maxwell's hypotheses.

The propagation of force through an ideal elastic solid makes the velocity of propagation depend upon two constants only, the density and the elastic constant. The first determines the inertia reaction and the second the elastic reaction per unit volume of the solid. Similarly in the propagation of the electric force through the electric and magnetic tubes of force in an ideal dielectric the velocity of propagation depends upon two constants only; the specific inductive capacity of the tubes and their magnetic permeability. One determines the reaction of the electrical tubes of force, and the other the reaction of the magnetic tubes. These reaction constants determine the velocity of propagation through the electric and magnetic tubes in the same manner as density and elastic constant determine the velocity of propagation through ideal elastic bodies. The question arises, which of the two reaction constants of Faraday's tubes corresponds to the density and which to the elastic constant of material bodies? In other words, which of the two constants is characteristic of the inertia reaction of the tubes?

The generalized laws of Ampère and of Faraday, which I call the Maxwell laws, suggest a permissible

answer to this question. They indicate a scheme which demands one fundamental flux, the electric flux, called here the primary flux. A variation or velocity of motion of the electric flux generates, according to the first Maxwell law, magnetic forces and corresponding magnetic fluxes which in an isotropic dielectric are proportional to the impressed magnetic forces, the factor of proportionality being the magnetic permeability of the tubes of the magnetic field. If, therefore, we consider the magnetic flux of the field, thus generated, as the momentum of the varying or moving electric flux, since it is proportional to its rate of variation or velocity of motion, then the electrical field generated, according to the second Maxwell law, by the variation of the magnetic flux will be due to the change of this momentum. According to this scheme the permeability constant in the electromagnetic theory would correspond to density in the theory of propagation through elastic solids.

Electron physics supports this scheme. It traces the origin of all magnetic forces of magnets to the orbital motions of electrons. This reminds us of the old Ampèrean conception. Magnetic tubes of force associated with so-called permanent magnets are, according to electron physics, the result of the motion of electric tubes of force attached to electrons. Maxwell always associated with magnetic tubes of force the momentum of some electric motions. What Faraday called the electrotonic state he called the electrokinetic momentum of a circuit, that is, the magnetic flux interlinked with the circuit. The reactions of varying magnetic tubes of force are, therefore, inertia reactions and their reaction constant, the permeability, should, as already pointed out, be considered as corresponding to the density of elastic solids, whereas the reciprocal of their specific inductive capacity corresponds to the elastic constant. Faraday's tubes of force in free space have, in electromagnetic units, a permeability equal to unity and, measured in the same system of units, an exceedingly small specific inductive capacity. They behave, therefore, like incompressible elastic bodies of moderate density but of very high elastic constant for shearing strains. It is equal to 9×10^{20}. Hence the great velocity of propagation of electromagnetic disturbances through tubes of force in free space, as experimentally verified by Hertz.

Electrical propagation through ideal dielectrics, including the vacuum, demands, according to the above picture, nothing more than Faraday tubes of electric force capable of two distinct reactions, one an electrical reaction and the other a magnetic, that is an inertia, reaction. The tubes react like a material medium of reasonable density but of most extraordinary stiffness. But neither this similarity to material bodies nor anything else in our present knowledge of electrical phenomena justifies the hypothesis that they consist of a substance which has qualities of ordinary matter in bulk. One can not resist the temptation of asking the question: What are these tubes made of? I venture, therefore, to offer the following pardonable suggestion.

Our ideas of these tubes are associated with our concepts of electrical charges which are the terminals of the tubes when they have a terminal. In this we follow in the footsteps of Faraday. It is not an unreasonable hypothesis to assume that they are made of the same fundamental substance of which the electrical charges are made. The name "electricity" may, therefore, be reserved for that substance, whatever it may be, so that we may say: The medium which transmits electrical disturbances is "electricity," meaning thereby the substance out of which electrical tubes of force are made. Light is an electrical disturbance and it is, according to this view, transmitted by electricity. The concept suggested by the word "electricity" is much more definite than that suggested by the words "lumeniferous ether," because we associate with electricity two perfectly well-known and experimentally determinable reaction constants, that is, the reaction constants of the primary flux of force at rest and in motion. These are the only attributes that we can dynamically predicate of a material substance, hence the concept "electricity" is dynamically just as definite as the concept "material substance"; the concept "ether" is not.

Perhaps I have dwelt too much upon that part of the electromagnetic theory which is a little outside of the daily problems of the electrical engineer. Some people think that it is entirely outside of the theory which underlies electrical engineering problems. Permit me to show you, as briefly as I can, that this is not so, and that the same form of laws and the same dynamical methods apply to electrical engineering problems as to the problems discussed above. Electrical engineering problems deal with actions and reactions in electrical and magnetic circuits and so does the general electromagnetic theory. I have pointed out how starting with Coulomb's law a more general law was formulated for the field of force due to electrical or to magnetic charges at rest, the law of equality of actions and reaction in every volume element of the field in static equilibrium. The validity of this law was maintained for the dynamical equilibrium of variable fields when Ampère's and Faraday's laws were formulated by Maxwell in their most general form. The principle of conservation of energy demands that this law be always true irrespective of the physical character of the circuit or of the process of generating the impressed forces. This furnishes then the most fundamental basis in theoretical electrical engineering. It may be stated as follows:

In every circuit or part of a circuit the algebraic

sum of electrical reactions is equal to the algebraic sum of the impressed electric actions.

Omit the words "electrical" from this statement and you have the most fundamental law in Newton's dynamics, showing that "electricity" obeys the same fundamental law which ponderable matter obeys.

Take for an illustration an electrical circuit in which we have a constant electromotive force, generated by a voltaic cell and a constant current flowing through a conducting wire. Consider any two points on the wire. Heat is generated in the wire between these two points and, therefore, there must be an electrical reaction in the wire between these two points. Heat is the result of the work done against this reaction by the impressed electrical force transmitted by the battery. This reaction may be called a *resistance reaction,* whereas the impressed action is the difference of potential between these two points. The law of equality of action and reaction says: The resistance reaction is equal to the difference of potential. This relation is independent of the so-called "Ohm's Law." When, however, the wire is maintained at constant temperature then its resistance reaction is found by experiment to be proportional to the current; this empirically established characteristic of most metal wires is called Ohm's law. It really is not a law any more than Joule's rule for the rate of heat generation by a current flowing through a metal wire. Both are accurate empirical descriptions of a physical characteristic of most metal wires. It is occasionally stated, with some show of disappointment, that the flow of current through a gas does not obey Ohm's law, which really means that the resistance reaction is not proportional to the current, and that it can not be described as simply as the resistance reaction of a metal wire. That a conducting gas should react differently than a conducting metal wire should not surprise anybody; but it seems that it does.

Consider, as another simple illustration, a toroidal magnetic circuit consisting of several different radial sections of different kinds of steel separated from each other by small air gaps and magnetized by a current flowing through turns of wire wound around the toroid. The total magnetomotive force generated by the current is given by Ampère's law. Each part of the magnetic circuit receives its definite share of the total magnetomotive force; this share is the magnetizing force impressed upon that part of the circuit. In each part of the magnetic circuit the impressed magnetizing force is equal to the magnetic reaction of that part, so that according to the fundamental law the sum of the magnetic reactions is equal to the total impressed magnetic actions, which is the magnetomotive force. This is the fundamental law, whereas the usual method of calculating, roughly, the magnetic flux from impressed magnetizing forces and reluctances by making use of a new kind of Ohm's law for the magnetic circuit is, in my opinion, a misleading use of the word law. This spurious Ohm's law is abandoned, of course, as soon as we attempt to devise an experimental method for measuring hysteresis losses during a complete cycle of magnetization, but we do not abandon the dynamical law that in every part of the magnetic circuit the magnetizing force is equal to the magnetic reaction. On the contrary, we could not interpret without it the hysteresis losses during cyclic magnetizations.

When in a network of linear conductors alternating current generators are located at various points of the network, the current distribution in the network can be calculated by setting up equations for each circuit, which state the fundamental dynamical law that in each circuit the algebraic sum of electrical reactions is equal to the algebraic sum of impressed electromotive forces, generated by the alternators. To call these equations mathematical expressions of a Kirchhoff law, as some do, is unpardonable abuse of language. Kirchhoff gave the *rule* that for any circuit in a network of metallic wire conductors in which there are sources of constant electromotive force the algebraic sum of the electromotive forces is equal to the algebraic sum of the products of current and Ohmic resistance; but he never suspected that this is a special case of the fundamental dynamical law given above.

It is true that in 1858 Kirchhoff, in his analysis of electrical propagation along an overhead telegraph wire, stated correctly the relation between the electrical reactions at any element of the wire, and in this statement he was guided by Thomson's discussion of electrical propagation over a submarine cable. But neither Thomson nor Kirchhoff were aware of the general law, stated above. Maxwell's electromagnetic theory had not yet been published, and prior to that publication the general law implicitly contained in this theory, and which is to-day the foundation of electrical engineering, could not be formulated.

The several simple examples cited above suffice to illustrate clearly that electrical engineering problems, on their purely scientific side, are formulated in the same way as the problems in the general electromagnetic theory. Their solutions are obtained by the application of the same form of the fundamental laws employing the same methods of reasoning and the same terminology which Newton had formulated when he created the science of dynamics. The possibility of describing electrical phenomena in terms of Newton's concepts and language is one of the greatest achievements of Faraday and Maxwell. Law, description and hypothesis were never employed with greater effect than by the genius of these great prophets of the electrical science.

M. I. PUPIN

COLUMBIA UNIVERSITY

SAMUEL TAYLOR DARLING
1872–1925

Samuel Taylor Darling, who met with a fatal automobile accident while traveling as a member of the League of Nations Malaria Commission near Beirut, Syria, on May 20, 1925, was for twenty years one of the foremost American students of tropical medicine, especially in the field of medical zoology.

Dr. Darling was of English parentage and came from a long line of clergymen. Early in life he exhibited that independence of thought and action which contributed so largely to his later success. After trying out several fields he decided upon medicine as a career and attended the College of Physicians and Surgeons at Baltimore, where he received his degree in 1903 with the honor medal for highest rank in a class of over seventy. The following two years he spent as resident pathologist in the Baltimore City Hospital. Dr. Darling considered himself primarily a pathologist, although he designated his field as tropical medicine in "American Men of Science." However, he will be known to the scientists of the future as a medical zoologist since almost all his published work is on this subject. The stimulus for these investigations in medical zoology was received at Panama. Already in 1903 he showed promise of being an investigator by publishing a paper on typhoid orchitis. He was appointed intern and physician in the Ancon Hospital in the Panama Canal Zone in 1903. Here he exhibited the qualities that led to his being made chief of the laboratories of the Isthmian Canal Commission in 1906; a position he held until 1915.

During the ten years Dr. Darling was in Panama, he became interested in various parasitic organisms that cause disease in man and animals. He observed three cases of histoplasmosis (1906) the causative organism of which he thought to be a protozoon, but which was later found to be a fungus. He then became interested in sarcosporidia and described various species, one of which, from the opossum, was named by Brumpt in his honor, *Sarcocystis darlingi* in 1913. Two of the very few authentic cases of sarcosporidia in man were reported by Darling (1909 and 1919) and the "blind alley" theory which he proposed to account for their presence is now generally accepted. It will be impossible in the space available to comment critically on all of the important work done by Darling in Panama. Soon after reaching the Canal Zone he began studying malaria and published a number of papers dealing with both the malarial organism and its mosquito vectors. Among the other subjects dealt with in his publications of this period are relapsing fever (1909), trypanosomiasis in horses (1910, 1911, 1912), leishmaniasis (1910, 1911), intestinal helminths (1911), Haemoproteus and haemogregarines (1912), *Linguatula serrata* (1912), anaphylactic serum disease (1912), Endamoebae (1912, 1913), anthrax (1912), piroplasmosis (1913), beriberi and scurvy (1914), Endotrypanum (1914) and arteritis syphilitica obliterans (1915).

In 1913–1914 Dr. Darling was selected to accompany General Gorgas on a sanitary mission to the Rand Mines and Rhodesia, South Africa, where his expert opinion was desired in connection with the high mortality of workers in the diamond mines. In 1915 Darling joined the staff of the International Health Board of the Rockefeller Foundation and continued with this organization until his death. His first project while a member of this board was to head a medical commission which from 1915 to 1917 studied the causes of anemia among the people of Malaya, Java and Fiji. Part of the results of the work of this commission are contained in a book of 191 pages published in 1920 in collaboration with M. A. Barber and H. P. Hacker on "Hookworm and Malaria Research in Malaya, Java and the Fiji Islands." Several other investigations on hookworm disease were carried on by Darling especially on mass treatment (1920, 1922) and on the geographical and ethnological distribution of hookworms (1920). On his return from the Far East, Darling was sent to Sao Paulo, Brazil, where he served as professor of hygiene and director of the Laboratories of Hygiene in the Medical School. Here he established an excellently equipped laboratory for teaching and investigation and carried on work principally with hookworm disease and malaria. He was forced by illness in 1920 to return to the United States, where he became fellow by courtesy in the department of medical zoology of the School of Hygiene and Public Health of the Johns Hopkins University.

In 1922 Darling established for the International Health Board a field laboratory for the investigation of malaria at Leesburg, Georgia. Here for the following three years he did some of the best work of his life both as an investigator and as a teacher, since many young men were sent to his laboratory to obtain training in field work before proceeding to various parts of the world as field directors of malaria control campaigns.

Dr. Darling was an honorary fellow of the Royal Society of Tropical Medicine and Hygiene, London; the only other American so honored was General Gorgas. He was to have delivered the annual address to this society in June. He took an active part in various societies. He was president of the Canal Zone Medical Association in 1908, fellow of the Amer-

ican Medical Association, president of the American Society of Tropical Medicine, 1924–1925, vice-president of the American Society of Parasitologists, 1925, a member of the National Malaria Committee and a corresponding member of various foreign societies. In 1923 he was given the honorary degree of doctor of science by the University of Maryland Medical School and the medal of merit was bestowed upon him posthumously by the Lebanon Government of Syria.

A review of Darling's published work does not adequately represent his activities since he worked on a number of problems about which he did not publish. To accomplish what he did in twenty years of scientific work required perseverance and industry such as is exhibited by very few scientists. Those who were so fortunate as to have worked with Dr. Darling learned to know him as an independent leader, a most charming and interesting companion and an investigator of the highest ideals. Mrs. Darling has very kindly presented Dr. Darling's library, which contains large numbers of books and reprints on medical zoology and allied subjects, to the department of medical zoology, of the School of Hygiene and Public Health of the Johns Hopkins University, where it will be known as the Samuel Taylor Darling Library and will constitute a fitting memorial for one who did so much to further the progress of scientific work in medical zoology.

R. W. HEGNER

THE JOHNS HOPKINS UNIVERSITY

SCIENTIFIC EVENTS

THE CENTENARY OF THE INVENTION OF PHOTOGRAPHY

ACCORDING to a cable to the *Christian Science Monitor* by Sisley Huddleston, the International Congress of Photography celebrated on June 29 and throughout the week the one hundredth anniversary of the French discovery of the photographic methods by Joseph Nicéphore Niepce. On June 30 a commemorative plaque to Louis Daguerre was unveiled and a reception held at the Hotel de Ville. On July 2 there was a meeting at the Sorbonne, with President Doumergue present, under the chairmanship of von Delbos, secretary of technical instruction. Among other functions was the opening of a retrospective exhibition of photography by Paul Leon, director of fine arts. By order of the government, the centenary was observed in the schools, where lessons were given on the subject of Niepce. Great interest was taken in the occasion and the newspapers emphasized the part taken by France in modern progress.

Nicéphore Niepce, the French savant, was born at Chalon-sur-Saone in 1765. He devoted himself with his brother Claude to natural scientific study. It was the development of the lithographic process of printing in 1811 which interested him in the reproduction of designs.

His first experiments with a sheet of tin covered with a composition sensitive to the action of light, on which he placed designs, were simple. He employed a dark room, but his main preoccupation was the search for suitable chemicals. He utilized a box with a hole admitting light, this being the precursor of the camera. M. Daguerre, working in association with him, perfected the appliances. It was not, however, until 1841 that the Daguerreotype was drastically improved, and a few years later photographs on glass were made and albumen employed.

There were many workers in the same field from the second quarter of the nineteenth century onward, but it is agreed that the greatest innovators were Niepce and Daguerre. Both were poor and remained poor, though they have since made the fortunes of many others.

Now that photography has become an art and has brought about the cinema, with possibilities hitherto unsuspected, France is doing honor to a neglected pioneer.

THE ANNUAL MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

THE annual meeting of the American Institute of Electrical Engineers was held at Saratoga Springs, N. Y., from June 23 to 26, with an attendance of more than 900. A well-diversified program was carried out, and several new and interesting developments were recorded. The meeting was notable for the manner in which the technical committee reports were presented and discussed and for the discussions of papers presented at the technical sessions. Outstanding topics that were reviewed concerned the best distribution system to use, the status of cables, developments in oil breakers and new features of transformers. New tools described and discussed included the quadrant electrometer or electrostatic wattmeter, an oscillograph for measuring transients and the klydonograph for measuring line disturbances.

Inspection trips filled the afternoons, an especially noteworthy excursion being made to the General Electric Company's works at Schenectady. Excursions by motor and train to Lake George and other scenic points were also well attended.

At a "feature" meeting on Thursday evening Director W. E. Wickenden, of the Society for the Promotion of Engineering Education, gave an address covering his impressions of European educational

methods, and at an evening meeting on Wednesday Samuel S. Wyer presented a paper on Muscle Shoals and W. S. Lee told of the 540,000-hp. developments at Ile Maligne, on the Saguenay River, in Quebec.

The incoming president, Dr. Michael I. Pupin, professor of electromechanics at Columbia University, and president of the American Association for the Advancement of Science, succeeds Farley Osgood.

THE THIRD NATIONAL COLLOID SYMPOSIUM

THE Third National Colloid Symposium, sponsored by the colloid committee of the division of chemistry and chemical technology of the National Research Council, was held at the University of Minnesota on June 17, 18 and 19. There were 356 persons registered as attending the scientific sessions. A study of the registration cards shows that this was truly a national symposium, inasmuch as the registrants came from thirty different states and four foreign countries.

Of the 356 registrants, 90 were connected with industrial firms or other agencies not directly associated with educational institutions. The remainder were from educational institutions. The twin cities, St. Paul and Minneapolis, claimed 167 of the registrants, of which number 138 were associated in some capacity with the University of Minnesota, 7 with other educational institutions in the twin cities and 22 with industrial firms.

The registration by states was as follows: Minnesota, 205; Wisconsin, 29; Illinois, 22; Ohio, 15; New York, 11; Michigan and Pennsylvania, 9 each; New Jersey, 6; North Dakota, South Dakota, California and Iowa, 5 each; District of Columbia and Missouri, 3 each; Massachusetts, Arkansas, Washington, Indiana, Montana, Maryland, Tennessee and Connecticut, 2 each; Colorado, Georgia, Kansas, Mississippi, North Carolina, Oklahoma, Oregon and Texas, 1 each. There were two registrants from Canada, and one each from Germany, Hungary and Czecho-Slovakia. Professor Herbert Freundlich, of the Kaiser Wilhelm Institute, Berlin-Dahlem, was the guest of honor.

R. A. GORTNER

APPOINTMENTS AT THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

THE Board of Scientific Directors of the Rockefeller Institute for Medical Research announces the following appointments and promotions:

New Appointments:

Members:

Dr. Winthrop J. V. Osterhout
Dr. Florence R. Sabin

Associates:

Dr. Robert T. Hance
Dr. Marian Irwin

Assistants:

Dr. Lawrence W. Bass
Dr. William W. Beattie
Dr. Francis H. Case
Mr. William C. Cooper, Jr.
Dr. Charles A. Doan
Dr. Philip Finkle
Mr. Earl S. Harris
Dr. Charles H. Hitchcock
Dr. Philip Levine
Dr. Richmond L. Moore
Dr. Ralph S. Muckenfuss
Dr. Richard E. Shope
Dr. Hans Theiler

Fellow:

Dr. Telémaco S. Battistini

Promotions:

Fellow to Assistant:

Dr. David Davidson
Dr. Philip Reichert

Dr. Laura Florence, hitherto an associate in the department of animal pathology, has accepted an appointment as assistant professor of histology and embryology at the New York Homeopathic Medical College and Flower Hospital.

Dr. Stuart Mudd, hitherto an associate in pathology and bacteriology, has accepted an appointment as assistant professor of experimental pathology at the Medical School of the University of Pennsylvania, and as associate in pathology at the Henry Phipps Institute for the Study, Treatment and Prevention of Tuberculosis.

Dr. Christopher H. Andrews, hitherto as assistant in the department of the hospital, has accepted an appointment as assistant to Professor Francis R. Fraser, Medical Unit, St. Bartholomew's Hospital, London.

Dr. Douglas Boyd, hitherto an assistant in the department of the hospital, has accepted an appointment as assistant resident in surgery at Lakeside Hospital, Western Reserve University, Cleveland, Ohio.

Dr. Arnold M. Collins, hitherto an assistant in pathology and bacteriology, has accepted an appointment on the chemical research staff of the E. I. du Pont de Nemours Company, Wilmington, Delaware.

Dr. Robert Elman, hitherto an assistant in pathology and bacteriology, has accepted an appointment as assistant in surgery, department of surgery, Washington University Medical School, St. Louis, Missouri.

Dr. Joseph H. B. Grant, hitherto an assistant in pathology and bacteriology, has accepted an appointment as house officer in pediatrics at the Johns Hopkins Hospital.

Dr. C. Philip Miller, Jr., hitherto an assistant in pathology and bacteriology, has accepted an appointment as assistant professor of medicine in the graduate school of medicine of the University of Chicago.

Dr. Waro Nakahara, hitherto an assistant in biophysics, has accepted an appointment as associate pathologist at the Government Institute for Infectious Diseases, Tokio Imperial University, and research associate at the Institute of Physical and Chemical Research of Tokio.

Dr. Everett S. Sanderson, hitherto an assistant in the department of animal pathology, has accepted an appointment as assistant professor of bacteriology in the Medical School of the University of Virginia.

Dr. David T. Smith, hitherto an assistant in pathology and bacteriology, has accepted an appointment as pathologist at the New York State Hospital for Incipient Tuberculosis, Ray Brook, New York.

Dr. Elmer L. Straub, hitherto an assistant in pathology and bacteriology, has accepted an appointment as assistant resident pathologist at the University of Louisville, Kentucky.

Dr. Chester M. Van Allen, hitherto an assistant in pathology and bacteriology, has accepted an appointment as assistant professor of surgery in the graduate school of medicine of the University of Chicago.

THE NEW BUILDING OF THE MARINE BIOLOGICAL LABORATORY

THE new building and laboratories of the Marine Biological Laboratory, at Woods Hole, were dedicated on July 3. Charles R. Crane, president of the Board of Trustees, presided and addresses were given by Professor Frank R. Lillie, director; Professor Edmund B. Wilson, Columbia University, and Professor Edwin G. Conklin, Princeton University. The addresses were followed by an inspection of buildings and work, with afternoon tea in the library. The first of the series of evening lectures was delivered by Professor W. J. V. Osterhout, his subject being "Absorption and accumulation."

In 1920 the first plans for the new building by Coolidge and Shattuck were before the trustees, and with the cooperation of the National Research Council a search for funds was begun. In January, 1924, one million four hundred thousand dollars were in hand. This fund represents contributions of the Rockefeller Foundation, the Carnegie Corporation, Mr. John D. Rockefeller, Jr., and the Friendship Fund. In addition, Mr. Charles R. Crane agreed to be responsible for the cost of the new building beyond the original estimate of five hundred thousand dollars. Nine hundred thousand dollars of the total sum has been invested for endowment. Previous to the acquisition of the new funds, the educational plant and other resources of the laboratory were valued at about five hundred thousand dollars, so that the laboratory now administers some two million dollars, represented by plant and investments.

While the new building provides ample space for the expansion of the library, a commodious lecture hall and rooms for the general offices, the provisions important for scientific work are the research rooms, supplied not only with fresh and salt water for the aquaria, but with arrangements for the control of light and temperature and with the several forms of electric current. In addition there are special installations, such as X-ray rooms, galvanometer room, photographic rooms, experimental dark rooms, constant-temperature rooms, etc., to meet the requirements for advanced biophysical and biochemical work.

SCIENTIFIC NOTES AND NEWS

THE Council of the National Academy of Sciences has accepted the invitation of the University of Wisconsin to hold the autumn meeting of the Academy in Madison, Wisconsin, on November 9, 10 and 11. Arrangements for this meeting will be made by the local committee, the chairman of which is Professor C. K. Leith, University of Wisconsin, Madison, Wisconsin.

PROFESSOR ERNST COHEN, of the University of Utrecht, has been elected president, and Dr. James F. Norris, of the Massachusetts Institute of Technology, vice-president, of the International Union of Pure and Applied Chemistry, at its recent meeting in Bucharest. It was decided to hold the next meeting in the United States in 1926.

THE honorary degrees of doctor of science were conferred upon M. Niels Bohr, professor of physics and director of the Institute of Theoretical Physics at Copenhagen, and on Brigadier-General Charles G. Bruce, leader of the Mount Everest Expedition, by Oxford University on June 24.

DR. JOHN JOLLY, professor of geology and mineralogy in the University of Dublin, has received the honorary degree of doctor of science from the University of Cambridge.

THE honorary degree of doctor of engineering has been conferred upon Sir Dugald Clerk by the University of Liverpool.

DR. ALBERT E. WHITE, professor and director of engineering research in the University of Michigan, has had conferred on him by Brown University the honorary doctorate of science.

SYRACUSE UNIVERSITY has conferred the degree of doctor of science on Dr. Horatio B. Williams, professor of physiology in Columbia University.

DR. GEORGE GAILEY CHAMBERS, professor of mathematics at the University of Pennsylvania, has received from Dickinson College the honorary degree of doctor of science.

AT its annual commencement Berea College conferred the honorary degree of doctor of science upon Professor Willard Rouse Jillson, state geologist and director of the Kentucky Geological Survey.

DR. R. W. THATCHER, director of the New York State Agricultural Experiment Station, was awarded the degree of doctor of laws at the commencement exercises at Hobart College on June 15.

DIRECTOR G. I. CHRISTIE, of Purdue University Agricultural Experiment Station, has received the honorary degree of doctor of science from the Iowa State Agricultural College.

AT the anniversary meeting of the Linnean Society on May 26, the society's Linnean medal in gold, its highest award, was presented to Professor Francis Wall Oliver, professor of botany in the University of London at University College since 1888.

THE Albert medal has been awarded by the Council of the Royal Society of Arts, England, to Lieutenant-Colonel Sir David Prain, "for the application of botany to the development of the raw materials of the empire." The medal was instituted in 1863 by the society and is awarded annually "for distinguished merit in promoting arts, manufactures and commerce."

THE National Surgical Society of France has awarded the quinquennial Lannelongue prize, consisting of a gold medal and 5,000 francs, to Dr. George Crile, of Western Reserve University.

DR. LOUIS A. BAUER, director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, has been elected to membership in the Institute of Coimbra, Portugal.

THE committee on the award of institute prizes of the American Institute of Electrical Engineers has made the following awards: The "transmission prize" for 1924 to R. D. Evans and R. C. Bergvall, authors of a paper entitled "Experimental analysis of stability and power limitations," and the "first paper prize" for 1924 to Murray F. Gardner, author of a paper entitled "Corona investigation on an artificial line."

DR. E. A. ECKHARDT, who for six years has been in charge of the sound laboratory of the Bureau of Standards, has resigned to join the staff of the newly organized research department of the Marland Oil Company of Oklahoma.

DR. ROBERT P. BIGELOW, professor of zoology and parasitology in the Massachusetts Institute of Technology, has been relieved from the duties of librarian in order to devote his entire time to teaching and research. William N. Seaver has been promoted from assistant librarian to be librarian with the title of assistant professor.

ANNOUNCEMENT is made by Chas. M. Upham, director of the highway research board of the National Research Council, that Professor S. S. Steinberg, of the University of Maryland, has been designated acting secretary of the new investigation begun by that board on the development of earth roads.

DR. R. L. RIGDON, of the Stanford University Medical School, has been made emeritus professor of genito-urinary surgery and appointed consultant in urology at Lane Hospital.

ON the thirtieth anniversary of his connection with the university, Dr. A. Carle, professor of surgery, Turin, was presented with a scholarship fund and a two-volume collection of scientific works dedicated to him.

PROFESSOR WILLIAM ERNEST DALBY, F.R.S., has been appointed a member of the Royal Commission on Awards to Inventors to fill the vacancy caused by the resignation of Robert Young.

AT the anniversary meeting of the Linnean Society, London, the following officers were elected: *President,* Dr. A. B. Rendle; *treasurer,* H. W. Monckton; *secretaries,* Dr. B. Daydon Jackson (general), Dr. W. T. Calman (zoology) and J. Ramsbottom (botany).

THE following appointments have been made by the Royal College of Surgeons, England, for the ensuing year: Hunterian professors—Sir Arthur Keith, on the evolution of the higher primates; Arthur Edmunds, on pseudo-hermaphrodism and hypospadias and their surgical treatment; J. E. Adams, on the surgery of the jejunum; E. M. Woodman, on malignant disease of the esophagus; A. T. Edwards, on the surgical treatment of phthisis and bronchiectasis; A. L. Abel, on the treatment of cancer of the esophagus; H. W. B. Cairns, on neoplasms of the testicle. Arris and Gale lecturers—Stanford Cade, on cholecystography; Alfred Piney, on the importance of haematology in surgery. Erasmus Wilson lectureship—C. E. Shattock, demonstrations on pathology. Arnott demonstratorship—Sir Arthur Keith, demonstrations on the contents of the museum.

BEGINNING in January, 1926, Dr. Maynard M. Metcalf will be at the Johns Hopkins University, Homewood, Baltimore, Md., where he has accepted appointment as research associate in zoology. In September, 1925, he will go to South America, chiefly to collect Opalinidae for an intensive study of the sexual phases of the life history. He will spend several months at the Museo Nacional in Montevideo and

shorter periods in Rio de Janeiro, Buenos Ayres, Chile and Barro Colorado Island in the Panama Canal Zone. The Bache Fund of the National Academy of Sciences has made a grant toward the expenses of the trip.

Dr. John A. Miller, director of Sproul Observatory at Swarthmore College, has left for Sumatra as head of the expedition to observe the total solar eclipse of January 14, 1926.

Dr. S. F. Blake, of the Bureau of Plant Industry, is spending several weeks at museums in Paris, Geneva and London for the purpose of studying type specimens of certain American species of plants.

W. B. Kilgore, dean of agriculture of the North Carolina Agricultural Experiment Station, has resigned. He has gone to Europe in the interest of the American Cotton Exchange and will return at the end of July.

At the request of the government of Chile, Dr. John D. Long, assistant surgeon general, U. S. Public Health Service, will become technical adviser in public health to the Chilean ministry of hygiene.

Dr. Albert Perry Brigham, of Colgate University, and Mrs. Brigham, are spending the summer and autumn in Europe, chiefly in France, Switzerland and England.

Dr. Thorne M. Carpenter, of the Nutrition Laboratory of the Carnegie Institution, Boston, has recently returned from a five-months' tour of university laboratories, clinics and research institutions in Norway, Sweden, Denmark, Germany, Switzerland, Austria, Hungary, France, Belgium, Holland and Great Britain. During the trip he gave thirty lectures on the investigations of the laboratory in twenty-two cities before various scientific organizations.

Dr. W. R. B. Robertson, of the department of zoology of the University of Missouri, and Dr. David D. Whitney, of the department of zoology of the University of Nebraska, are spending a part of the summer in the Kansas State Agricultural College. Dr. Robertson is carrying on cytological research, using the pedigreed grouse locusts (*Tettigidae*). Dr. Whitney is teaching zoology in the summer school and carrying on research with the rotifers of the region of Manhattan.

Dr. Percy Norton Evans, head of the department of chemistry at Purdue University for twenty-five years, died on July 3, at the age of fifty-six years.

James Bolton MacBryde, professor of chemistry at Virginia Polytechnic Institute, has died at the age of fifty-nine years.

Professor Walter Scott Hendrixon, professor of chemistry at Grinnell College, Iowa, has died, aged sixty-six years.

Dr. Lesley H. Spooner, physician to the out-patient department of the Massachusetts General Hospital and formerly instructor in bacteriology at the Harvard Medical School, died on June 29, aged forty-four years.

Professor Hermann Kossel, director of the Hygienic Institute in Heidelberg and brother of the physiologist, Albert Kossel, of the same university, recently died at the age of sixty-one years.

M. Anghel Saligny, the Rumanian engineer, who was responsible for many engineering works of Rumania, including the bridge over the Danube at Cernavoda and the ports of Constanza, Galatz, and Braila, has died at Bucharest.

The tenth annual meeting of the Optical Society of America will be held at Ithaca, N. Y., on October 29, 30 and 31, 1925.

A climatological congress, arranged by the Davos Institute for Alpine Physiology and Tuberculosis Research, will be held at Davos, Switzerland, on August 30 and 31.

We learn from *Nature* that the fourteenth International Geological Congress is to be held in Madrid during May and June, 1926. The provisional list of subjects for general discussion includes the following topics: The world's reserves of phosphates and pyrites, geology of the Mediterranean and of Africa, Cambrian and Silurian faunas, Tertiary vertebrates and foraminifera, Hercynian folds, modern theories of metallogeny, vulcanism and the application of geophysical studies to geology. Excursions covering a wide range of interests are being arranged. The general secretary for the congress is Senor E. Dupuy de Lôme, Geological Institute of Spain, Plaza de los Mostenses 2, Madrid.

Organization of a national Engineering Community Trust, with an endowment of $20,000,000, under the headship of the Engineering Foundation and with headquarters in New York, is planned by American engineers and has the approval of Alfred D. Flinn, director of the Foundation, who said: "Mr. Swasey intended his gifts for the Engineering Foundation to be but the beginning of a trust for the engineering community, which would grow to great size by many additions from engineers and other persons who are interested in, or who have profited from, engineering."

Public lectures will be given at the New York Botanical Garden on Saturday afternoon at 4 o'clock during the months of July and August as follows:

July 4—"Trinidad: Its flora and scenery," Dr. F. J. Seaver; July 11—"How to think about evolution," Dr. C. Stuart Gager; July 18—"Seeds: Their tricks and traits," Dr. William Crocker; July 25—"Lilies," Dr. A. B. Stout; August 1—"The forest resources of the northwest and their conservation," Professor George B. Rigg; August 8—"Flowers of the summer garden," Kenneth R. Boynton; August 15—"The rose mallows, cultivated and wild," Dr. A. B. Stout; August 22—"The dismal swamp of Virginia," Dr. Arthur Hollick; August 29—"Scenery of our western mountains," Le Roy Jeffers.

THE program of the Astronomy and Physics Club of Pasadena has during the last three months included the following subjects: March 13—"The distribution of valence electrons in crystals," Dr. M. L. Huggins, National Research Fellow; April 3—"Recent work on the absorption of X-rays," Dr. F. K. Richtmyer; April 10—"On the theory of diamagnetism," Dr. S. J. Barnett; April 17—"Intensity of lines in multiplets," Dr. H. N. Russell; April 24—"Secondary emission due to positive ion bombardment," A. L. Klein; May 1—"The interior of stars," Dr. S. Rosseland; May 15—"Reports on the Washington meetings," Dr. R. A. Millikan; May 22—"Two-electron jumps," R. A. Millikan and I. S. Bowen; May 29—"Thallium fluorescence excited by mercury light," Dr. Stanislaus Loria.

THE Navy Department is making preparations to observe the solar eclipse January 14 from the East Indian Island of Sumatra. It will send an expedition from the United States Naval Observatory at Washington, headed by Captain F. B. Littell. The party will include George H. Peters and George M. Raynsford, astronomers from the Naval Observatory, and Professor J. A. Anderson, of the Mount Wilson Observatory. In addition there will be a corps of enlisted men including medical attendants and seamen. The expedition will sail from San Francisco September 1 on the *Chaumont* to prepare for the observations. Three tons of equipment have already been shipped to Norfolk. The observers will take motion pictures of the eclipse and pictures of the activities of the party and a vessel will be sent to Sumatra to conduct radio experiments during the eclipse period.

DR. WILLARD C. RAPPLEYE has resigned as director of the New Haven hospital and as professor of administrative medicine at Yale University to accept the appointment of executive officer of the recently organized commission of medical education. He will be director of the survey of medical education which will be started by the Association of Medical Colleges. Other members of the commission to make the survey are President A. Lawrence Lowell, of Harvard University; President Ray L. Wilbur, of Stanford University; President Walter A. Jessup, of the University of Iowa; Chancellor Samuel P. Capen, of the University of Buffalo; Sir Robert Falconer, president of the University of Toronto; Dr. Walter L. Bierring, of the National Board of Medical Examiners, and former Dean George Blumer, of the Yale Medical School.

UNIVERSITY AND EDUCATIONAL NOTES

DR. CLARENCE C. LITTLE has resigned the presidency of the University of Maine to become president of the University of Michigan, in succession to the late Dr. Marion L. Burton.

ADOLPH H. SCHULTZ, research associate in the department of embryology, Carnegie Institute of Washington, has been appointed associate professor of physical anthropology in the Johns Hopkins University.

DR. EDWARD SAPIR, director of the Victoria Museum, Ottawa, has been appointed associate professor of anthropology at the University of Chicago.

DR. HORACE SCUDDER UHLER has resigned his position as associate professor of physics at Yale College to become head of the department of physics in Gettysburg College.

DR. RICHARD A. MUTTKOWSKI, associate professor of vertebrate zoology at the University of Idaho, has become professor of biology at the University of Detroit. During the months of July and August Professor Muttkowski will be in Glacier Park, investigating lakes and streams for the Bureau of Fisheries.

REVEREND JAMES B. MACELWANE, S.J., assistant professor of geology and director of the seismographic station at the University of California, has been appointed professor of geophysics and seismology and director of the seismographic station and of a new department of geophysics and seismology in the Saint Louis University, Missouri. Dr. Perry Byerly, Jr., instructor in physics in the University of Nevada, has been appointed instructor in geology and director of the seismographic station at the University of California.

RECENT appointments to the staff of the State Agricultural Experiment Station at Geneva include C. B. Sayre, of the University of Illinois, as associate in research (horticulture); Leon K. Jones, of the University of Wisconsin, as associate in research (plant pathology), and L. R. Hawthorn, a graduate student at Cornell University, as assistant in research (horticulture).

PROMOTIONS in the faculty of the Case School of Applied Science have been announced as follows: As-

sociate Professor C. L. Eddy was made professor of railroad engineering; O. M. Stone was advanced to assistant professor of descriptive geometry, W. E. Nudd to assistant professor of drawing, T. D. Owens to assistant professor of electrical engineering, C. F. Prutton to assistant professor of chemical engineering, H. D. Churchill to assistant professor of mechanics, Max Morris to assistant professor of mathematics and K. H. Donaldson to assistant professor of mining engineering.

Professor R. W. Reid has handed in his resignation from the chair of anatomy at the University of Aberdeen, which he has held since 1889.

Professor Richard Goldschmidt, junior director of the Kaiser Wilhelm Institute for Biology, Berlin, has declined the chair of zoology in Berlin University.

DISCUSSION AND CORRESPONDENCE

THE "UNDERTOW"

People who have had long experience in bathing in Lake Michigan state—and they state correctly—that there are, at certain times and places, currents which may carry a swimmer away from shore and therefore put him in danger of drowning. The bathers speak of such currents as "undertow." Professor Walter C. Jones[1] writes that the undertow is a myth, and he gives the impression that there are no currents dangerous to bathers in Lake Michigan. It is possible that some reader who trusts this impression and acts upon it may be drowned in consequence. Therefore I write to state that there *are* dangerous currents in Lake Michigan and that they are the currents which the bathers (correctly or incorrectly) name "undertow"; and I shall give a brief account of *one* set of conditions under which these currents are produced.

During a northeast storm at Chicago there is a very considerable movement of surface water toward the shore. But this movement is complicated by certain local conditions. The wind from the lake blows, as a rule, not at right angles to the shore, but obliquely from a northerly direction. Consequently, as the wind drives the surface water before it, it causes a drift along-shore southward. At a point here and there on the beach the southward drift is blocked by a pier—a straight, solid wall extending vertically out from shore. On meeting the pier, the southward drift is turned from its course, and in some cases it produces a current which flows directly away from shore, which is strong at the surface and extends to an unknown depth, and which is swift enough to prevent the average swimmer (at least) from making any headway against it. Near 75th Street, Chicago, when I used to swim there, we bathers made it a rule to keep far away from such piers as I have described during a northeast storm.

[1] Science, Vol. LXI., April 24, 1925, p. 444.

The fact that Professor Jones never encountered such a current is not at all surprising. It simply means that he never swam in the lake under the special conditions of time and place under which the current comes into existence. Shore currents in general are local and variable phenomena; that very fact makes them dangerous.

The warning here given to bathers in Lake Michigan should be extended to surf bathers elsewhere. There are many surf beaches on which a dangerous outward current exists at certain times, and the people call it an "undertow." I do not know whether they are correct in naming it an undertow, but the important fact remains that the dangerous current exists and that "undertow" is the common name for it. At any bathing beach in the United States, if an intelligent and trustworthy native tells you that he has at times observed an undertow on that beach, do not dismiss his statement as a myth, but understand what he means by it. He means that he has observed a dangerous current of some sort. Give heed to his warning.

Wallace Craig

Biophysics Laboratory,
Harvard Medical School

I had just got the salt water out of my throat after an encounter with what would commonly be called an "undertow" when I read Professor W. M. Davis's article on the subject, and believe that I can offer some relevant observations. They will support Mr. Davis's protest against the common conception of an "undertow," although I can assure him that the seaward current is sometimes more persistent than he is willing to concede.

I might, perhaps, be classified as an expert swimmer, although not as a powerful or fast one. That is, I can swim several miles without resting, when in practice, and use the breathing system employed in the Australian crawl. Because swimming and breath control are automatic, I was able to observe the conditions in this "undertow," despite the alarm one feels when the conditions of the bath are not of his choosing.

I went swimming a few days ago at Carmel-by-the-Sea. There was a light offshore breeze. Carmel has a "pocket beach" of the most pronounced type, about three miles across at the entrance, a couple of miles deep and rounded in the center. It is exposed to the full sweep of the Pacific, and shelves quite rapidly to deep water.

The water was waist deep in the trough when I started to swim. I had taken only a few strokes when I glanced toward shore and saw that it was nearly a hundred yards farther away. I let down in a trough and touched bottom with my toes, but drifted outward into water that was over my head. There was no perceptible difference between the rate of flow at the surface and near the bottom—it was all outward.

After that, I began swimming shoreward, but went steadily seaward, in spite of the repeated breakers that went over my head. Perhaps, as Mr. Davis contends, the entire current changes with each breaker, but if so, this was an instance in which the outflow was far more powerful, in its effect on a swimmer, than the inflow. I could observe that the shore was steadily receding, and people on shore told me afterward that I kept going out while swimming in. That point is definite, and it was not confined to a single trough. At least half a dozen breakers went over during this phase.

Next, I came to an apparent standstill just under the crest of the outermost breaker. While a dozen breakers were passing, my swimming and the inflow of the breakers just about balanced the outflow of the troughs.

The last phase consisted of a powerful shoreward drive of the breakers, four or five of them, with little outward movement in the troughs. These breakers, with my swimming, took me into shallow water.

The only point I would flatly challenge in Mr. Davis' article is that there can be no "undertow" in a pocket beach without an onshore wind. I noticed the offshore wind in particular, because of the drift of the clouds in an afternoon when the sunny intervals were comfortable.

But in the main the "undertow" was not an undertow. The troughs all ran outward, and if there was a conflict of currents in the breakers, it was not noticeable.

I think Mr. Davis's article overlooked one important point in the analysis of these offshore currents, and that is the succession of high swells and low swells. I started to swim at the end of a succession of high swells, when there was a great amount of water to run off the beach. The succeeding low swells—and small breakers—could not stem this outward movement. Later came another series of high swells and big breakers, the outgoing troughs were completely flooded and the general movement of the water was landward. I know that while I was going out, the breakers were small, while just before they began to carry me shoreward they were curling six feet above my head.

I can add two or three observations which may help to explain the belief in an "undertow." The trough is a steady current seaward, which carries all objects at its own speed. The breaker is a tempestuous dash of water, which goes well past a swimmer before it checks his outward movement. This creates the impression that the main current is seaward, because the seaward current is the more effective as a carrier.

In the second place, the inexperienced swimmer, if taken out by the receding water of a succession of big breakers, loses control of his faculties before he is brought in by the next succession of big breakers. He goes under, and that is the end of him, and he seems to have been pulled under by an undertow when in fact the water merely piled on to him.

The fact is, though, that "undertows" are believed in a thousand miles from the ocean. Whenever somebody strangles in a freshwater mill pond, there is some newspaper reporter to characterize it as the work of a mysterious undertow.

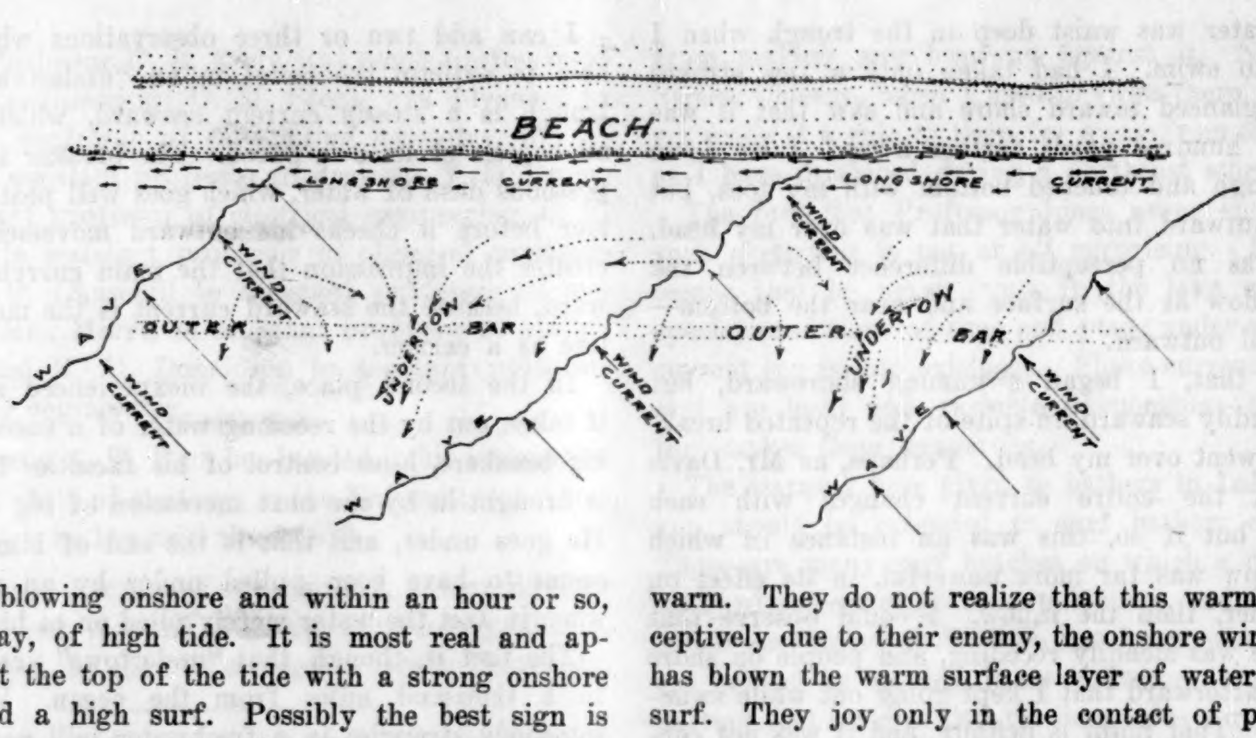
The combination of powerful breakers and a bottomless trough can be quite uncomfortable without any actual undertow, but in the case I have described I found that the bad feature was the light specific gravity of the breaker after it had begun to froth. A swimmer breathes out through his nose, or holds his breath, by exerting pressure from his lungs slightly greater than, or equal to, the pressure of the water in his nostrils. Meeting the accustomed pressure becomes as natural, and as automatic, as breathing in the air. I found that in the frothy breakers I breathed out too fast, with the result that I kept gulping salt water. Let me emphasize that ability to control the breath is far and away the most important factor in dealing with tumultuous water. Without it, swimming ability is next to worthless. A poor swimmer who is a good "water breather" will come through currents that the most powerful athlete, lacking breath control, would struggle against in vain.

In the second place, a person caught in a seaward current should swim flat on the surface and offer all possible resistance to the breakers, so that they will pick him up instantly, out of the receding trough, and carry him on their crest.

I. BRANT

THE flat sandy beaches of our Atlantic Coast have a menace for bathers which is usually spoken of as the "undertow," though this is a grossly misleading term. This menace is elusive, for it varies widely in violence and at times is entirely absent so that even some scientists suspect it to be a myth.

Generally speaking, this menace is real when a



wind is blowing onshore and within an hour or so, either way, of high tide. It is most real and apparent at the top of the tide with a strong onshore wind and a high surf. Possibly the best sign is water warmer than the air. The cautious bather entering the surf near high tide may well take alarm if he find the water much warmer than usual, the surf high and a strong wind blowing from off the sea. If he will look along the beach carefully it is quite likely that he will discover, at varying intervals, streams like small rivers running through the surf directly out to sea. These streams or rivers are the so-called "undertow," and the swimmer may well avoid them, the menace, the widely heralded, sadly misnamed "undertow."

The "undertow" is not, as some imagine, a hidden current of water running along the bottom all along the beach and of approximately equal velocity everywhere. It is a sort of river, a stream showing on the surface deep and powerful, easily perceptible, running with the velocity of a mill race. So swift and powerful is it that a motorboat could not stem its sweeping current. It will carry brick, large rocks and even chunks of lead far out to sea. The most powerful swimmer will find himself helpless as a babe in its rushing grasp. He will find his utmost exertion of no avail in opposition, though if he understands its nature he may easily swim across it to the quiet zone on either side. He may find this unfitly named as a zone of quiet, for it is a surf zone where wild waves break with greatest vigor, but their trend is shoreward and in it he may with skill and patience win the beach and safety.

The "undertow" is not always present; days and days may elapse with hardly a sign of it. Now comes the full moon, the "spring" tides, a fresh ocean breeze and a powerful surf begins to mount. The beach is delightful, there is life and action in nature and bathers are enticed into the surf where they are overjoyed to find the water delightfully warm. They do not realize that this warmth is deceptively due to their enemy, the onshore wind, which has blown the warm surface layer of water into the surf. They joy only in the contact of pleasantly warm water, until one more adventurous than the rest suddenly recedes farther and farther from them and only, long afterward, they realize their menace in the misnamed "undertow."

Practically all sand beaches have what is called an "outer bar," a shoal, entirely submerged, cast up by the first breaking surf waves. This outer bar is parallel with the beach and from one to six hundred feet seaward from it. This bar and the beach form a narrow basin.

Waves are of two kinds—"oscillation" and "translation." Deep water waves are of the oscillation type, in which the water undulates but does not move forward. When this type reaches shoal water it changes and becomes the translation type in which the water itself is carried forward with the wave. The hardy bather who has breasted a powerful surf and been thrown about by the tons of moving water readily realizes that surf waves are actually moving water waves and much different from those he encounters off shore.

Practically all surf waves are of the translation type, and the water in them is carried forward to the beach and into the basin formed by outer bar and beach. Under favorable conditions these waters "heap up" and fill this basin to overflowing. Obviously there must be an escape for these heaped-up waters and the misnamed "undertow" is their method and means of escape. Low points form in the outer bar and widen and deepen until a sort of river appears every few hundred feet along the beach. This is the misnamed "undertow," the heaped-up waters carried shoreward by wind and wave escaping back to the sea.

The wind itself tends to heap up water in the shore basin, but this is of little moment as compared

with the enormous quantities swept there by the surf waves.

Let the bather beware, the "undertow," however incorrectly named, is real and a serious menace to the most powerful swimmer. Beware the treacherously warm water and stay away from the outer bar at high tide with onshore wind and strong surf.

M. P. HITE

ELIZABETH CITY, N. C.

AMONG a number of letters received from observant surf bathers on the Atlantic and Pacific coasts, most of whom agree that there is no such thing as a persistent undertow, is one from Miss L. R. Craig, Agawam, Massachusetts, who gives a graphic account of a true undertow experienced when swimming opposite the middle of a concave or pocket beach between rocky points at Hampton, New Hampshire, in July, 1923; although she is an expert swimmer, a current was felt like that of a river, except that it was below the surface so that it dragged her under water; she was pulled down as if by suction in water over her depth. She escaped by swimming obliquely to the shore, as it was impossible to make headway against this undertow. The note is added that "strong men have been drowned at Hampton Beach by undertow." This would therefore seem to be an example of the kind that I mentioned in my article on "The Undertow Myth," except that no mention is made of an on-shore wind as its cause; but the day was "cold and dreary," thus implying a wind from the ocean.

It is because of the occasional occurrence of such verified undertows that I regret the use of that ominous term by Mr. Hite in his letter above, as applied to surface streams. It appears to me also that he gives too great importance to the transformation of oscillatory into translatory waves as the surf rolls on shore, and also to the off-shore bar, as causes of the local, outflowing streams. An on-shore wind would tend to brush the surface water shoreward without a bar on the bottom and without that transformation at the surface; and compensating outflows might then be produced at various points along a straight beach. But the term, undertow, should not be applied to them.

Mr. Brant misunderstands me if he thinks I am not "willing to concede" the existence of any current, surface or elsewhere; such currents are well attested by observation; for example, the general seaward surface drift that he describes as occurring for a time in a bay on the California coast; but such a current appears to be quite different from a possible "undertow," either there or elsewhere. Furthermore, I see no sufficient ground in Mr. Brant's observations for his "flat challenge" of my suggestion that a real *under*tow may be caused in a bay by an *on*shore wind: the *surface* current that he observed in a bay during an offshore wind seems to me aside from the case. In the interest of clear discussion, I think it is undesirable to use the word "current," in describing the oscillatory movement of the water in swell and surf: the essence of a "current" is a persistent movement in one direction over a considerable area for a considerable time. True, the term is used in naming the flood and the ebb of the tides, which are, in relation to great oceanic spaces, local and temporary; but as they run over areas of scores or hundreds of miles and for periods of several hours, they seem to be currents. For waves, terms like crest advance and trough recession seem more appropriate, as more likely to convey the true and intended meaning.

The difficulty in the undertow problem lies in the fragmentary nature of the facts: and so in the curious offshore and onshore drift that Mr. Brant describes, his account is naturally enough, as it depended on a swim in the bay, incomplete. It might be possible to explain the phenomena if they were more fully recorded.

W. M. DAVIS

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PAUL TO THE THESSALONIANS

PROFESSOR C. W. E. MILLER, of the Greek department of the Johns Hopkins University, has kindly pointed out to me that in SCIENCE of April 17, 1925, page 419, the well-known admonition of Paul to the Thessalonians, in being requoted, suffered "startling maltreatment of the Greek words." Professor Miller gives me the following as the exact wording and accentuation of the verse:

πάντα δοκιμάζετε,
τὸ καλὸν κατέχετε.

If you will kindly publish this correction I shall be obliged.

CHARLES D. SNYDER

ERROR IN HERALDRY

THE "fable" in the issue of SCIENCE for May 29 involves a serious error in heraldry. There is no such charge as a "bar sinister." A bar is a band horizontally across the shield and can, therefore, be neither dexter nor sinister. The indication of bastardy is the "baton sinister," a narrow band not reaching to either side of the shield but lying obliquely from the sinister area to the dexter.

HENRY LEFFMAN

THE GREEN RIVER FORMATION

AMONG the continental formations of North America commonly described as lacustrine is the Green River (Eocene), which covers large areas of northwestern Colorado, southwestern Wyoming and northeastern Utah. Since the formation is one of the principal sources of oil shale in the western United States, geologists have studied various sections of it more or less intensively during the past decade and have obtained a large amount of information regarding the sedimentology and the fossil content. In a paper published under the above title, in the *Bulletin* of the American Association of Petroleum Geologists,[1] Professor Henderson has briefly reviewed this evidence to ascertain whether it accords with the view of the lacustrine origin of the formation, and, if so, whether the body or bodies of water in which the sediments were laid down were fresh or saline or alternately fresh and saline.

The formation, which is very generally considered a fresh-water lake deposit, is composed chiefly of fine-grained, even-bedded sediments, which, if not deposited in a lake, must have been laid down by streams meandering in broad valleys where shallow, temporary lakes were present. However, comparatively few strata showing cross-bedding, ripple-marks or mud-cracks, which would characterize this type of deposition, have been observed.

Fossils are numerous and are mainly of non-aquatic forms. Fresh-water fishes have been obtained principally from a single, thin stratum at two localities in Wyoming. The presence of so many skeletons in a thin layer of a lacustrine formation is difficult to explain, unless an arm of the lake were cut off and speedily desiccated. If the sediments are partly fluviatile, this accumulation could easily have taken place in isolated ox-bow lakes which were rapidly filled with sediments.

Well-preserved leaves of upland and lowland plants are abundant in the upper part of the formation far from any possible shore line. The aquatic plants are chiefly algae. The microscopic flora consists of conifer pollen, moss spores, annuli from fern sporangia and molds, all of which must have been carried from land; bacteria and blue-green algae, which can grow in both fresh and saline waters; Spirogyra and Protococcus, which are fresh-water types.

Insects are principally flying forms, whose wide distribution in the strata can be easily accounted for.

The most abundant and widespread fossils have been identified as the larvae of botflies or forms related to them. These larvae to-day infest land animals, and are not aquatic at any stage of their existence. The explanation of their distribution, if the Green River be lacustrine, is difficult.

It is evident from Professor Henderson's discussion that further intensive field work is necessary to determine the origin of certain parts of the formation. While probably most of the beds are fresh-water lake deposits, certain strata doubtless have been deposited by other agencies. The sedimentology of the formation should be thoroughly investigated, and more information secured regarding the paleontology. The identification of the botfly larvae needs confirmation. If these by chance should be some other form, the explanation of their distribution might be more easily made. In any event, it does not seem likely that these larvae had the habits of the modern types.

NORMAN E. A. HINDS
UNIVERSITY OF CALIFORNIA

[1] Vol. 8, pp. 662–668, 1924.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD OF MEASURING THE WATER TEMPERATURES OF LAKES AT DIFFERENT DEPTHS

THE measuring of the temperature of lake waters at various depths in connection with the study of the development of the thermocline, the percentage of saturation of oxygen and carbon dioxide and the distribution of life is a problem in which every limnologist is actively interested. The usual method of using the Negretti-Zambri reversing thermometer, while quite accurate after certain corrections have been made, is a rather slow and tedious procedure, even though several thermometers and lines are used at the same time. It is apparent that much time and labor would be eliminated by the use of some electrical indicating thermometer. The thermophone, described by Whipple, has not proven entirely satisfactory. The apparatus here to be described has been used successfully by the writer for three summers at the Iowa Lakeside Laboratory in taking daily temperature readings on Lake Okoboji with what seems to be accurate results. Feeling that other limnologists have felt the need for such apparatus the following brief description is given.

The indicator used is the Charles Engelhard type P–1 indicator provided with two centigrade scales of fifteen degrees each, divided into tenths of a degree. One scale reads from zero to fifteen degrees, the other from twelve to twenty-seven degrees centigrade, allowing an overlap on the two scales for checking purposes. While these scales are sufficient in range for ordinary work on the main lake, for ponds or shallow water which will give higher readings in mid-

summer, a third scale could be added. The markings on the scales are far enough apart so that much finer readings than tenths of a degree can be made. The indicator is of rugged construction so that it has given no serious trouble during the three summers used and seems to be in good condition for the coming summer as well.

This indicator is mounted in a double gimbel box to compensate for the rocking of the boat due to wave motion. Except on extremely rough days no difficulty has been experienced in reading the scales when the engine of the boat is not running. The gimbel box is placed in a larger box filled with loose excelsior to minimize the effects of the vibrations due to the running of the engine when going from one place to another.

The bridge box is of the Wheatstone type and is provided with a four-way switch. Switch point No. 1 is for the scale reading from 0–15, No. 2 for the scale 12–27, No. 3 is voltage proof for scale No. 1 and No. 4, the voltage proof for scale 2. It is possible, therefore, to check each scale before using. The resistance box is operated by two 1½ volt dry cells, which are easily replaced when worn out, usually not more than once during the summer. It would make for considerable compactness and ease in handling if the resistance box and the indicator were incorporated in one box, which could easily be done at the factory.

The thermometer, which is connected to the resistance box by a three-wire, 150 foot water-proofed lead, is the regular Engelhard 100 ohm platinum wire resistance thermometer. It is made up of a little spiral of highly resistant platinum wire wound upon a fused quartz tube which, in turn, is hermetically sealed into an outer quartz tube by fusion. This is then mounted in a perforated brass tube fitted with a moisture proof terminal head. The thermometer requires but little attention save to renew occasionally the rubber gaskets in the head so that the terminals may not get water soaked.

The advantages of this instrument are its reliability, the ease with which it may be used, the rapidity in making readings, the continuous line of readings from top to bottom and the possibility of checking up the readings as the thermometer is being raised. The thermometer responds very quickly to changes of temperature, one or two minutes are usually sufficient for the needle of the indicator to come to rest.

The following table gives a comparison of the readings as the thermometer is lowered from the surface to the bottom of the lake and again as it is raised.

The reading for August 16, 1922, was taken at 9 A. M. The sky was clear, there was very little breeze so that the lake was almost flat, although the day before was rough. This accounts for the evenness of the temperature in the epilimnion. For the same date in 1923 the reading is for 1:20 P. M., and the lake again was fairly smooth but somewhat rough in the morning. For August 16, 1924, the reading was taken at 8 A. M., with a northwest wind blowing at

	Aug. 16, '22. Air, 25.4° C.		Aug. 16, '23. Air, 26.5° C.		Aug. 16, '24. Air, 16° C.	Thermocline. Aug. 16, 1922.	
Meters.	Down.	Up.	Down.	Up.	Down.	Meters.	Centigrade.
0	22.80°	22.90°	22.30°	22.40°	18.70°		
1	22.75°	——	22.20°	22.25°	18.80°	13	21.40
2	22.70°	——	22.15°	22.15°	18.78°	13¼	21.30
3	22.70°	——	22.10°	22.00°	18.68°	13½	21.09
4	22.70°	——	22.00°	22.00°	18.60°	13⅝	20.89
5	22.70°	22.70°	21.90°	21.88°	18.60°	13¾	20.70
6	22.50°	22.50°	21.85°	——	18.52°	13⅞	20.60
7	22.40°	22.40°	21.80°	21.80°	18.52°	14	20.50
8	22.30°	22.25°	21.80°	21.80°	18.50°	14⅛	20.30
9	22.00°	22.00°	21.80°	21.75°	18.50°	14¼	20.30
10	21.80°	21.80°	21.30°	21.20°	18.42°	14⅜	20.00
11	21.65°	21.60°	21.10°	21.10°	18.40°	14½	19.83
12	21.50°	21.50°	20.90°	21.00°	18.40°	14⅝	19.72
13	21.40°	21.35°	19.70°	20.00°	18.32°	14¾	19.60
14	20.80°	20.50°	17.20°	17.40°	18.25°	14⅞	19.50
15	19.50°	19.20°	15.00°	15.00°	16.20°	15	19.20
16	17.70°	17.60°	13.60°	13.50°	15.30°	15⅛	19.05
17	16.80°	16.50°	12.95°	12.90°	13.80°	15¼	18.90
18	16.10°	15.60°	12.50°	12.50°	13.00°	15⅜	18.82
19	15.00°	14.60°	12.20°	12.20°	12.00°	15½	18.60
20	14.10°	14.10°	11.80°	11.80°	11.30°	15⅝	18.30
21	13.70°	13.50°	11.70°	——	11.05°	15¾	18.10
22	13.55°	13.50°	11.55°	——	10.85°	15⅞	18.00
23	13.30°	13.25°	11.30°	——	10.75°	16	17.95
24	13.10°	13.10°	11.15°	——	10.60°	16⅛	17.80
25	12.80°	12.75°	11.05°	11.10°	10.50°	16¼	17.70
26	12.80°	——	11.05°	——	10.30°	16⅜	17.65
27	12.40°	——	11.03°	——	10.20°	16½	17.50
28	12.40°	12.35°	11.00°	——	10.10°	16⅝	17.20
29	——	——	11.00°	——	10.05°	16¾	17.10
30	——	——	10.95°	10.85°	9.90°	16⅞	16.99

the rate of 649 feet per minute. The summer of 1924 was a cold summer so that the surface temperature never reached as high as 22° C.

FRANK A. STROMSTEN

IOWA LAKESIDE LABORATORY

SPECIAL ARTICLES

RETARDATION OF THE ACTION OF OXIDASES BY BACTERIA

IN a variety of plants and animals there are found substances which are capable of accelerating certain oxidations. These substances, in the majority of cases, resemble the hydrolyzing enzymes in the minute quantities in which they are effective and in their instability towards heat. The discovery of these oxidizing enzymes we owe to Schönbein, who employed guaiac as a means of detecting them. According to Bach and Chodat,[1] the oxidizing enzymes which occur in living tissues in reality consist of two parts: the one part, oxygenase, acting as the carrier of the oxygen; the other part, peroxidase, facilitating the transfer of the oxygen to the material undergoing oxidation. Onslow[2] believes that in plant tissues there are two separate enzymes acting as above.

It has long been known that milk would turn blue in the presence of guaiac, showing the presence of oxidases. The writers have found that stale milk would have no effect on a solution of guaiac. The staleness of milk is due to the growth of bacteria. This paper is an attempt to correlate the number of bacteria present in the milk with the destruction of the oxidases. It is an attempt to show that the presence of bacteria will hinder and finally stop all oxidations, through oxidizing enzymes.

In all the observations the following method was employed. Fresh Grade B milk was obtained at the store. Two hundred cc were put into a sterile bottle; corked with cotton and kept in an icebox at a temperature of 12° C. for further tests. From this stock supply there were daily drawn 5 cc of milk by means of a sterile pipette and tested as follows. To 2 cc in a sterile test tube was added 1 cc of a 1 per cent. solution of guaiac and the time determined for the blue color to disappear. The remaining 3 cc were treated in the following way in order to determine their bacterial count.

Four dilutions were made up: 1 to 100; 1 to 10,000; 1 to 1,000,000 and 1 to 100,000,000. One of each of the last three dilutions was plated out into a separate petri dish, and agar-agar added. The dish was rotated so as to form an emulsion between the milk and the agar. They were then kept at a temperature of 37.5° C. for a period of five days and then the colonies of bacteria counted. This was done daily at the same hour until the milk taken from the stock bottle failed to give a blue color with the guaiac solution. All apparatus used was sterilized in an autoclave, with live steam for two hours, and then allowed to cool before using.

The results are given in Tables 1 and 2. They show that at first the increase in bacteria accelerated the action of the oxidases as shown by the increasing length of time it takes for the blue color of the guaiac to disappear. But as the bacteria continue to increase the color of the guaiac disappears more and more quickly until finally there can be gotten no color with the guaiac. In the observations there is quite an agreement between the number of bacteria present and the time taken for the color of the guaiac to disappear.

TABLE I

SAMPLES OF 2 CC OF MILK PLUS 1 CC OF GUAIAC. TIME IN MINUTES IS GIVEN FOR THE BLUE COLOR TO DISAPPEAR

Sample of Milk / Number of Days	1	2	3	4	5	6	7	8	9	10
A	29	33.5	37.5	41	40	28	20	*	—	—
B	51	55.0	59.0	40	21	19	17	15	—	—
C	——	48.0	45.0	40	20	18	*	——	—	—

* No blue color obtained.

TABLE II

BACTERIAL COUNT IS GIVEN IN MILLIONS OF BACTERIA PER CC OF EACH SAMPLE OF MILK USED

Sample of Milk / Number of Days	1	2	3	4	5	6	7	8
A	.06	.41	1.5	2.54	500	——	600	1,100
B	.05	.25	2.5	18.6	400	1,100	22,000	37,000
C	——	.60	7.0	12.0	900	——	——	——

It will be seen that the three observations taken on the fourth day are practically equal in respect to time, although the bacterial count (Table 2) varies. Is this failure of the oxidases to change guaiac due to an accumulation of bacterial toxins? This phase of the problem will be determined in our next paper.

Summary: The staleness of the milk prevents the action of these oxidases to oxidize this solution of

[1] Bach and Chodat, Centr. f. Biochem, 1903, 1, pp. 417 and 457.

[2] Onslow, *Biochem. Jour.*, 1920, 14, pp. 535, 541.

guaiac to guaiac blue. This prevention is due to the number of bacteria present. Up to about three millions of bacteria per cc the action of the oxidases is accelerated and from then on their action is retarded.

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CULTIVATION OF THE VIRUS OF TOBACCO MOSAIC BY THE METHOD OF OLITSKY

RECENT publications of Olitsky[1] on the cultivation of the virus of mosaic disease of tobacco and tomato attracted unusual attention. The intense but fruitless search which has been made by numerous workers for the causal agent of this pathological condition has made it evident that the problem presents many difficulties. Perhaps no type of plant disease has been more seriously studied by pathologists during recent years than mosaic. It is not surprising, therefore, that Dr. Olitsky's announcement of artificial cultivation of the virus should receive immediate and enthusiastic consideration.

The objective aspect of Olitsky's experiments is extremely simple and should be easily duplicated by any one caring to make the test. The bearing of positive results in this connection on future studies of the general problem of mosaic would undoubtedly be very great, and any effort to verify the findings reported is fully warranted. With this in view, an exact repetition of the experiments described was undertaken. The method followed is essentially as follows. Eighty grams of young tomato tissues were minced and then mortared to a pulp. This was mixed with 250 cc of sterile, distilled water. The mixture was centrifuged for one hour at 1,500 to 2,000 revolutions per minute. The supernatant liquid was passed successively through two Berkefeld N size filters and disposed in 3 to 5 cc portions in small test tubes. This, if it was found to have a pH value between 5.3 and 6.0, constituted the "culture" medium. This medium was held at 28 to 30 degrees C. for seven days to insure sterility. The inoculum used at first consisted of Berkefeld V filtrate from inoculated tobacco and tomato extract. Later sap was drawn directly from the stems of infected plants by means of capillary glass tubes and placed at once into the culture medium. Each culture tube received either 0.1 to 0.2 cc of the infectious filtrate or 0.01 cc of the sap as an inoculum. Succeeding transfers were made by putting 0.1 to 0.2 cc from the first culture into a second as a subplant and so on indefinitely. This procedure, of course, made a series of dilutions of the original inoculum, and Olitsky concludes that growth must have taken place if a decrease of infectiousness did not accompany the succeeding transfers. Every detail of Olitsky's procedure was carried out as completely as possible with one single exception, namely, the use of tobacco instead of tomato plants as tests of the infectiousness of the various cultures. This should not, however, influence the results, as tobacco is quite as susceptible to mosaic as are tomatoes. An additional check (not used by Olitsky) was introduced by the use of sterile, distilled water as a "culture" medium. All dilutions or transfers were made at the same time and in the same manner in both the water and tomato extract. Ten plants were inoculated with each dilution in each of three series; so that the figures given below represent the number of infections in a population of 30 plants for each transfer number. The results of the three separate series of experiments, including more than 260 plants, are given in summary form here.

NUMBER OF PLANTS INFECTED IN THIRTY INOCULATIONS

Transfer No.	Water.	Extract.
1	5	5
2	3	3
3	1	1
4	3	0
5	1	0

The original undiluted filtrate which was used as an inoculum gave 21 infections in 30 inoculations. It is clear that so far as these results are concerned Olitsky's findings are not confirmed, for there is no indication of an increase of the virus as the transfers proceed. The water cultures gave a rate of infection slightly higher than those made in tomato extract in the higher dilutions. These data are, no doubt, too meager to establish conclusions contrary to those reached by Olitsky, but they suggest the desirability of greater accumulation of experimental evidence, and are given here in hopes that they may assist in keeping the question open until the facts are fully established. It appears to the writer not impossible that Olitsky's results may have an interpretation other than that indicated in his articles.

MAURICE MULVANIA

[1] Olitsky, Peter K., "Experiments on the cultivation of the active agent of mosaic disease of tobacco and tomato." SCIENCE, Vol. LX, No. 1565, 1924, p. 592; "Experiments in the cultivation of the active agent of mosaic disease in tobacco and tomato plants." *Jour. of Exp. Med.*, Vol. XLI, No. 1, pp. 129–136, 1925.

NORTH CAROLINA ACADEMY OF SCIENCE

THE twenty-fourth annual meeting of the North Carolina Academy of Science was held at State College, Raleigh, May 1 and 2, 1925. The academy is making an especial effort to help the cause of science

in the high schools and to that end has provided a prize to be administered by a committee for excellence in work in high school science. Present membership was reported as 250. Officers for the coming year were elected as follows: *President,* J. P. Givler, North Carolina College for Women; *Vice-president,* J. O. Halverson, Department of Agriculture, Raleigh; *Secretary-treasurer,* B. Cunningham, Duke University; *members of the executive committee,* H. B. Arbuckle, C. M. Heck, A. Henderson.

Officers for the North Carolina Section of the American Chemical Society are: *President,* F. E. Rice, State College; *secretary,* L. B. Rhodes, Dept. Agriculture, Raleigh; *councilor,* J. M. Bell, Univ. of North Carolina.

The following papers were presented:

Presidential address, *The life and habits of the honey bee:* H. B. ARBUCKLE.

Results of the plankton studies of Chesapeake Bay: BERT CUNNINGHAM, *et al.*

Variations of proteins in corn: H. B. ARBUCKLE and O. J. THIES, JR.

A study in the direction-sense of animals: J. F. DASHIELL.

Development of some disc fungi: F. A. WOLF.

The physiography of Brazos County, Texas: E. O. RANDOLPH.

Two rare types of abnormality in cotton seeds: S. G. LEHMAN.

Morphological ecology of certain Savannah plants: C. F. WILLIAMS.

Results of soft pork investigations: J. O. HALVERSON and E. H. HOSTETLER.

Seasonal catch of snakes at Raleigh: C. S. BRIMLEY.

New ideas concerning mass: A. H. PATTERSON.

Some Homoptera from Cuba: Z. P. METCALF.

Some properties of ice crystals: E. K. PLYER.

Meteorological inquiries from the viewpoint of 1795: L. A. DENSON.

Some factors affecting the growth of young rats: F. W. SHERWOOD.

Investigation on the germinating and heating of cotton seed in warehouse storage: E. E. RANDOLPH.

Loessial soil and the world's food supply: COLLIER COBB.

The excitation of the O-energy levels in tungsten by electron bombardment: O. STUHLMAN, JR.

The rate of rotation of a Foucault pendulum: K. B. PATTERSON.

Observations on conjugation in Spirogyra from living material: J. N. COUCH.

New water molds from the soil: W. C. COKER and J. V. HARVEY.

The present status of the high school science program: C. M. HECK.

An oil-bearing soft pelite from Ontario, Canada: COLLIER COBB.

Methods of investigation in social psychology: C. C. TAYLOR.

The structure of the atomic nucleus: A. H. PATTERSON.

Oil-bearing shales of North Carolina: F. C. VILBRANDT.

Models of elementary crystal structure from X-ray evidence: OTTO STUHLMAN, JR.

Riccia sorocarpa, Bisch: H. L. BLOMQUIST.

X-rays and their biological effects: L. H. SNYDER.

The effect of heat on the viscosity of some of our familiar lubricating oils: H. B. ARBUCKLE.

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